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Explanation and Demonstration in the Haller-Wolff Debate

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1. THE HALLER-WOLFF DEBATE: PREEXISTENCE VERSUS EPIGENESIS?

One issue that surfaces with regularity in studies on the problem of organic generation in the early modern period is the battle waged between preexistence theorists and advocates of epigenesis. Roughly, by preexistence, I mean the theory that, at the Creation, God preformed (to some degree at least) every living organism that would ever exist.[1] One especially distinct form of preexistence is the *emboîtement* theory, according to which each organic individual is encased within the reproductive organs of one of its parents (either the mother on the ovist theory or the father on the spermist or animalculist theory), its parent is encased within the reproductive organs of one of its parents, and so forth. This accounts for all organic individuals of every generation – all future members of a given species are found encased within the first member of that species upon creation. And roughly, by epigenesis, I mean the theory that posits a truly new development of organic form.[2] Upon coitus, matter

[1] I use the term "preexistence" to differentiate this theory from preformation. As Jacques Roger and Peter Bowler have both noted, there are two distinct theories to be considered, one of which specifies God as the creator of organic forms, and the other of which simply states that the organism is formed before conception, but by a natural agent (Jacques Roger, *The Life Sciences in Eighteenth-Century French Thought*, trans. Robert Ellrich, ed. Keith R. Benson [Stanford: Stanford University Press, 1963 (1997)]; 259–60; Peter J. Bowler, "Preformation and Preexistence in the Seventeenth Century: A Brief Analysis," *Journal of the History of Biology* 4 [1971], 221–2). As Bowler has shown, early modern authors themselves often used the term "evolution" to describe preformation, but with a pre-Darwinian meaning of that term (Bowler, "The Changing Meaning of 'Evolution,'" *Journal of the History of Ideas* 36 [1975]: 95–114.

[2] See Jacques Roger, "La notion de développement chez les naturalistes du XVIIIe siècle," in *Entre forme et histoire: La formation de la notion de développement à l'âge classique* (Paris: Meridiens Klincksieck, 1988), on the notion of "development." In that article, Roger notes that the term was

that seemed previously to be homogenous, undifferentiated, noncomplex, unorganized, and nonunified becomes heterogeneous, differentiated, complex, organized, and unified into a living, functional individual. The form not only develops anew but is actually brought into existence as this process continues, and the process is often considered one of *self*-development, even self-creation. Malebranche is frequently credited with the revival of preexistence in the seventeenth century,[3] while William Harvey coined the term "epigenesis" and developed that theory in the seventeenth century.[4]

frequently used in reference to preexistence, not epigenesis, but when thus used it does not mean creation of new organic parts but rather the growth and filling out of existing essential organic parts. Within the class of preexistence theorists, Roger also notes that the concept of development is more readily applied to Leibniz, for example, than Malebranche, due to the degree of organic development permitted on his theory of preexistence – a degree that I believe places his theory partway between preexistence and epigenesis.

[3] For example, he writes in the *Entretiens sur la métaphysique et sur la religion*, "At the time of creation, God constructed animals and plants for future centuries. He established the laws of motion necessary for making them grow. Now he is at rest because he does no more than follow these laws" (OC XII, 253–4/DMR XI, 196). There is some dispute as to whether Malebranche or Swammerdam (or even Malpighi) is to be credited with the revival of the theory in its seventeenth-century form. See Howard B. Adelmann, *Marcello Malpighi and the Evolution of Embryology*, 5 vols. (Ithaca: Cornell University Press, 1966), 2:869–70; Richard Aulie, "Caspar Friedrich Wolff and His 'Theoria Generationis', 1759," *Journal of the History of Medicine* 16 (1961): 124–44; Peter J. Bowler, "Preformation and Preexistence in the Seventeenth Century: A Brief Analysis," *Journal of the History of Biology* 4 (1971): 234 n. 34, 237; Bowler, "The Changing Meaning of 'Evolution'," 233; Daniel C. Fouke, "Mechanical and 'Organical' Models in Seventeenth-Century Explanations of Biological Reproduction," *Science in Context* 3 (1989): 365–81; Edward Ruestow, "Piety and the Defense of Natural Order: Swammerdam on Generation," in *Religion, Science and Worldview*, ed. Margaret Osler and Paul Farber (Cambridge: Cambridge University Press, 1985), 231 ff. For studies of Malebranche's theory of generation see, e.g., Andrew Pyle's essay in this volume (chap. 9) and Karen Detlefsen, "Supernaturalism, Occasionalism, and Preformation in Malebranche," *Perspectives on Science* 11(2003): 443–83; Pyle, *Malebranche* (London: Routledge, 2003); André Robinet, *Malebranche de l'académie des sciences* (Paris: Vrin, 1970); and Paul Schrecker, "Malebranche et le préformisme biologique," *Revue internationale de Philosophie* 1, no. 1 (1938): 77–97.

[4] For example, in his 1651 *Disputations Touching the Generation of Animals*, he writes that "an animal which is procreated by epigenesis draws in the material and at the same time prepares and concocts and uses it; at the same time that the material is formed, it grows.... The formative power of the chick takes the material to itself and prepares it, rather than finds it ready prepared, and the chick seems less to be made or given increase by another then by its own self" (William Harvey, *Disputations Touching the Generation of Animals*, translated and introduction by Gweneth Witteridge [Oxford: Blackwell Scientific, 1981 (orig. pub. 1651)], 204). Some commentators believe that epigenesis as a biological theory can be traced back to Aristotle (e.g., A. L. Peck, introduction to Aristotle, *On the Generation of Animals* [Cambridge, MA: Harvard University Press, 1963]; Anthony Preus, "Science and Philosophy in Aristotle's *Generation of Animals*," *Journal of the History of Biology* 3 [1970]:1–52). 1970). For studies of Harvey's theory of generation, see, e.g., James G. Lennox's essay in this volume (chap. 1) and Don Bates, "Machina Ex Deo: William Harvey and the Meaning of Instrument," *Journal of the*

The debate surrounding organic generation between the Swiss poet, botanist, anatomist, and politician Albrecht von Haller (1707–77) and the German doctor and professor of anatomy and physiology Caspar Friedrich Wolff (1734–94) is often considered a classic version of the preexistence-epigenesis debate in the eighteenth century. The crucial details of that debate as it is generally understood are as follows. Early in his career, Haller wavered on whether to accept preexistence or epigenesis, initially supporting animalculist preexistence, as had his teacher Boerhaave, then converting to epigenesis in order to account for experiments in grafting and the recent discovery that polyps regenerate themselves when severed[5] and his own observations that organic parts appear to develop gradually. He eventually lost faith in epigenesis at least in part due to his own extensive experiments on chicken eggs at various stages of their development, which convinced him that certain organic parts are preformed in the egg. Moreover, he believed that the functional organization of living beings seems to require an intelligent builder absent in epigenesis but most certainly present in preexistence, given that God is responsible for organic formation on that theory.[6] In his late work

History of Ideas 61 (2000): 577–93; Edward T. Foote, "Harvey: Spontaneous Generation and the Egg," *Annals of Science* 25 (1969): 139–63; and Roger French, "Two Natural Philosophies," in *William Harvey's Natural Philosophy* (Cambridge: Cambridge University Press, 1995). For a general historical account of the rise of epigenesis a century and a half after Harvey coined the term, see Helmut Müller-Sievers, *Self-Generation: Biology, Philosophy, and Literature around 1800* (Stanford: Stanford University Press, 1997).

[5] Abraham Trembley, *Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, en bras en forme de cornes* (Leiden: Jean & Herman Verbeek, 1744), 26; Albrecht von Haller, ed., *Praelectiones academicae in proprias institutiones rei medicae*, authored by Hermann Boerhaave, notes added by Albrecht von Haller, 6 vols. (Göttingen: A. Vandenhoeck, 1739–44), 5:504–6.

[6] There is some dispute among commentators about the role that Buffon's theory of generation played in Haller's conversion to preexistence after having endorsed epigenesis for a few years. Haller wrote a preface to the German translation of the second volume of *Histoire naturelle* (Haller 1752), the text of which had appeared the year before in French as *Réflexions sur le système de la génération de M. de Buffon* (Haller 1751). Some commentators believe that Haller's criticism of Buffon in this piece spurred his return to preexistence. For various approaches to this issue see Amor Cherni, "Haller et Buffon: À propos des Réflexions," *Revue d'Histoire des Sciences* 48 (1995): 267–305; and Cherni, *L'Épistémologie de la transparence: Sur l'embryologie de A. von Haller* (Paris: Vrin, 1998); Francis J. Cole, *Early Thories of Sexual Generation* (Oxford: Clarendon Press, 1930); François Duchesneau, "Haller et les theories de Buffon et C. F. Wolff sur l'épigĕnĕse," *History and Philosophy of the Life Sciences* 1 (1979): 65–100; Duchesneau *La physiologie des lumières: Empirisme, modèles et théories* (The Hague: Martinus Nijhoff, 1982), 281 ff.; Elizabeth, Gasking, *Investigations into Generation: 1651–1828* (Baltimore: Johns Hopkins University Press, 1967), 108 ff.; Shirley Roe, "The Development of Albrecht von Haller's Views on Embryology," *Journal of the History of Biology* 8 (1975):167–90; Roe, *Matter, Life, and Generation: Eighteenth-Century Embryology and the Haller-Wolff Debate* (Cambridge: Cambridge University Press, 1981), 26–32; Roger, *The Life Sciences in Eighteenth-Century French Thought*, 708 ff. For an account of the relation between regeneration and generation, see

Elementa physiologiae corporis humani (hereafter *Elementa*), he notes that while a snowflake could be produced by forces alone, an organism must be produced by forces and wisdom (EP 8:117–8). In his 1758 *Sur la formation du coeur dans le poulet* (hereafter *Formation*), Haller writes in support of preexistence:

> It seems to me very probable that, at all times, the essential parts of the fetus exist formed; true, not in the way that they appear in the adult animal: they are arranged in a way that allows certain prepared causes to hasten the growth of some of the parts, to delay the growth of other parts, to change positions, to render organs that were transparent visible, to give consistency to the fluid and mucous, and thus to end up forming an animal that is very different from the embryo, and yet in which there is no part that did not essentially exist in the embryo. (Haller 1758, 2:186; cf. EP 8:148–9)

And in his *Elementa*, he explicitly identifies God as the creator of organisms and the mother as the parent who hosts the germ (EP 8:143).[7]

In 1759, one year after the publication of Haller's *Formation*, Wolff published his dissertation, *Theoria generationis*, in which he defends an epigenetic account of generation according to which plant and animal fluids are secreted from the developing organism and are solidified into parts. The process of secretion and solidification is accomplished by means of the *vis essentialis*. Just as this force accounts for the absorption of nutrients from the earth and the distribution of them throughout plants in both generation and self-maintenance, so too is it responsible for the development of animal bodies during generation: "At the start of its development, the chicken embryo takes food from the substance of the egg. It is absorbed by a force that is not the heart's contraction, and neither the arteries nor the pressure caused by them in the neighboring veins nor their compressions by the activity of muscles.... This force is called the *vis essentialis*" in animals just as it is in plants (Wolff 1759, §168, 73). Wolff sent his dissertation to Haller and thus

Charles W. Bodemer, "Regeneration and the Decline of Preformationism in Eighteenth-Century Embryology," *Bulletin of the History of Medicine* 38, no. 1 (1964): 20–31.

[7] For sustained investigations of Haller's changing ideas on generation, see Cherni, *L'épistemologie de la transparence*, 29–68; Duchesneau, "Haller et les théories de Buffon et C. F. Wolff sur l'épigénèse"; Duchesneau, *La physiologie des lumières*, 277–90; Maria Teresa Monti, "Théologie physique et mécanisme dans la physiologie de Haller," in *Science and Religion/Wissenschaft und Religion: Proceedings of the Symposium of the XVIIIth International Congress of History of Science* (Bochum: Universitätsverlag Dr. N. Brockmeyer, 1989); Roe, "The Development of Albrecht von Haller's Views on Embryology"; Roe, *Matter, Life, and Generation*, chap. 2; and Richard Toellner, *Albrecht von Haller: Über die Einheit im Denken des letzen Universalgelehrten* (Wiesbaden: Franz Steiner Verlag, 1971).

began a direct and extended debate which lasted until 1777, the year Haller died. The exchange included a series of letters (Wolff's survive, Haller's are lost), along with two reviews by Haller of Wolff's work and a German version (much revised due to the intervening polemic) of Wolff's dissertation under the title *Theorie von der Generation* (1764).[8]

In her impressive study of the dispute, Shirley Roe indicates that the Haller-Wolff controversy is especially interesting because they interpret so differently the apparently shared observational data culled from their dissection of chickens during their formation and development.[9] Two points stand out from their dispute over the meaning of the evidence. First, Haller attributes the phenomenon of the gradual formation of parts to the transparency of those parts before they grow and gain the solidity which makes them visible, while Wolff attributes this phenomenon to the prior nonexistence of those parts. Second, Haller responds to the fact that the heart appears later than other organs by attributing this to its tiny size and, again, transparency, while, once again, Wolff attributes this phenomenon to the prior nonexistence of the heart. It is crucial for Haller to suppose the preexistence of the heart because he takes the stimulation of this organ by the semen as that which starts the heartbeat, and the heartbeat is that which starts the circulation of fluid through the transparent, collapsed body, thus bringing it to life and to a visible state. What might account for Haller's and Wolff's divergence on the issue of generation in light of the shared empirical data? Roe's approach is to turn to "a whole host of 'extrascientific' assumptions and expectations, which fundamentally colored the observational level of their debate."[10] She sketches three broad areas of disagreement between the two which together account for their different theories of generation. First, she claims that Haller holds a "mechanical view of physiological explanations" (90), while Wolff holds a view of nature closer to vitalism and does not believe that a reduction of life phenomena to mechanism

[8] For sustained accounts of Wolff's theory of generation and its development, partly Under the pressures of Haller's criticisms, see Duchesneau, *La physiologie des lumières*, 312–40; A. E. Gaissinovitch, "C. F. Wolff on Variability and Heredity," *History and Philosophy of the Life Sciences* 12 (1990): 179–201; Reinhard Mocek, "Caspar Friedrich Wolffs Epigenesis-Konzept: Ein Problem im Wandel der Zeit," *Biologisches Zentralblatt* 114 (1995): 179–90; Garhard H. Müller, "La conception de l'épigénèse chez Caspar Friedrich Wolff (1734–1794)," *Revista di Biologia* 77 (1984): 343–62; Shirley Roe, "Rationalism and Embryology: Caspar Friedrich Wolff's Theory of Epigenesis," *Journal of the History of Biology* 12 (1979): 1–43; and Roe, *Matter, Life, and Generation*, passim. For Wolff's influence upon the latter half of the eighteenth century, see A. E. Gaissinovitch, "Influence des travaux de Caspar Friedrich Wolff sur la biologie du XVIIIe siècle," in *Lazzaro Spallanzani e la biologia del settecento* ed. Giuseppe Montalenti and Paolo Rossi (Florence: Leo S. Olschki Editore, 1982).

[9] Roe, *Matter, Life, and Generation*, chap. 3.

[10] Ibid., ix.

is possible (108).[11] Second, Haller conceives of God as a providential God, and the beauty in structure and use in function found in living beings only serves to prove that God alone could have been directly responsible for the existence of each one (90–2, 119). Wolff conceives of God as less directly interventionist and so believes that he created the world such that it could generate living beings from its own sufficient power (111–12). Third, Roe believes that Haller is an empiricist in the Newtonian tradition, with strong antirationalist leanings, while Wolff is a rationalist in the tradition which he inherited from Leibniz through Christian Wolff, and this rationalism demands that Wolff give a sufficient reason for generation, whereas Haller feels no such compulsion (95, 105).

Roe's approach is surely valuable, and we learn a great deal about Haller and Wolff as natural philosophers from her study. While I have misgivings about some of the details of her analysis, I proceed not by directly dealing with those misgivings but by asking two more fundamental questions. First, are Haller and Wolff really seeing the same thing when they conduct experiments on living beings? This is a question about the techniques used in their experiments and how these techniques condition the way they see the empirical data. Second, what exactly *are* the theories of preexistence and epigenesis, and are they so clearly distinct and mutually exclusive as they are often portrayed to be? Frederick B. Churchill is surely right to note that in discussing this "awkward dichotomy" between preexistence and epigenesis, "a thorough analysis must tangle with those intractable questions about the meaning of 'novelty,' 'emergence,' 'coming-to-be,' and 'form.'"[12] In fact, some commentators have questioned (implicitly or explicitly) the strict division of these theories. Marjorie Grene and David Depew argue that Buffon's theory of generation, based on the hypotheses of organic molecules and the

[11] On this score, Roe is in line with many commentators who have interpreted the preexistence-epigenesis debate as a debate between mechanism and vitalism. According to this account, with the rise of mechanism, organic generation became impossible to explain, and so it was explained away by saying that God created all organic beings. While mechanism could explain organic growth, it could not explain organic generation. If one wishes to explain generation by appeal to epigenesis, then one had to abandon mechanism for vitalism so as to be able to explain organic formation. For examples of this general approach, see Theodore Brown, "From Mechanism to Vitalism in Eighteenth-Century English Physiology," *Journal of the History of Biology* 7 (1974): 176–216; Hans Driesch, *The History and Theory of Vitalism*, trans. C. K. Ogden (London: MacMillan & Co., 1914), 12; Stephen Jay Gould, forward to Clara Pinto-Correia, *The Ovary of Eve: Egg, Sperm and Preformation* (Chicago: Chicago University Press, 1997), xiv–xv; and E. S. Russell, *The Interpretation of Development and Heredity* (Oxford: Clarendon Press, 1930), 132–4.

[12] Frederick B. Churchhill, "The History of Embryology as Intellectual History," *Journal of the History of Biology* 3 (1970): 171.

internal mold (*moule intérieur*), brings together elements of both epigenesis and preexistence despite the belief of Buffon's contemporaries that he is an epigenesist.[13] Similarly, in the late nineteenth century, the German biologist Oscar Hertwig compared his theory of embryological development with that of August Weissmann and determined that the debate between them was essentially the old epigenesis-preformation debate.[14] Yet Jane Maienschein believes that their views "were neither as extreme nor were they as distinctly separated as previous preformationist or epigenetic views."[15] Such examples alert us to the caution we ought to take in referring to the "divide" between preexistence and epigenesis. It is helpful to retain skepticism on this matter when examining the details of the Haller-Wolff debate. François Duchesneau, for example, notes Haller's accommodation of some aspects of epigenesis.[16] While Haller and Wolff adopt elements from the rival generation theory, there is a salient difference between their theories, and recognizing this is helpful, both for gaining a better understanding of epigenesis and preexistence and for gaining a clearer understanding of Wolff's and Haller's different scientific methodologies.

I devote the next section of this essay to showing that while Wolff's theory of generation during the years of his dispute with Haller is surely quite different from Haller's, an argument could be made that this difference comes about because Haller and Wolff are engaged in different sorts of projects. According to this argument, Wolff simply describes the visible, sequential development of embryos whereas Haller is more interested in explaining what causal source could realistically give rise to the fetus. When we turn to Wolff's later work on heredity and variation, together with his paper on the nature of the *vis essentialis*, this interpretation gains further support since he seems to move closer to a preexistence stance when attempting to properly explain the process of generation. Still, I think this interpretation of Wolff is lacking, and so, in sections 3 and 4, I investigate the nature of experiment and explanation in

[13] Marjorie Grene and David Depew, *The Philosophy of Biology: An Episodic History* (Cambridge: Cambridge University Press, 2004), 82–7. Anna Tymieniecka argues that Leibniz's theory of generation also bears marks of both preexistence and epigenesis (*Leibniz's Cosmological Synthesis* [Assen, The Netherlands: Van Gorcum & Co., 1965], 142–51).

[14] Cf. August Weissmann, *Germplasm: Walter Scott's Contemporary Science Series*, 14, 1893.

[15] Jane Maienschein, "Preformation or New Formation – Or Neither or Both?" in *The Eighth Symposium of the British Society for Developmental Biology: A History of Embryology*, ed. T. J. Horder, J. A. Witkowski, and C. C. Wylie (Cambridge: Cambridge University Press, 1985), 79. If Weissmann's theory was a preformationist theory, it was, indeed, pre*formation* rather than preexistence, but this fact does not alter the point under consideration, and in fact I argue later that there can be a blurring of the line between epigenesis and preexistence as well.

[16] Duchesneau, *La physiologie des lumières*, 311.

their work, first detailing their reactions to Descarte's methodology in natural investigations and then turning to how their reactions to Descartes can help us accurately interpret their modes of experimentation. The latter work shows both how the interpretation of Wolff in section 2 is lacking and that Haller and Wolff actually see quite different things in their experimental manipulations of living beings. Throughout this essay, then, I aim to gain a clearer understanding of what essentially divides Haller's theory of generation from Wolff's, to show the defining impact of the nature of experimentation upon their theories of generation, and to indicate my points of departure from Roe's account of the conceptual underpinnings of these two thinkers' embryological theories.

2. EXPLANATION AND DESCRIPTION IN THEORIES OF GENERATION

J. S. Wilkie suggests that some versions of epigenesis are mere *descriptions* of embryonic formation and growth but that preexistence is a theory truly meant to *explain* that phenomenon,[17] thus implying that the two doctrines are not two different answers to the same problem but are rather different answers to different issues: while the epigenesist is not interested in providing an ultimate explanation for the observations, the preexistence theorist is, and if the epigenesist should shift emphasis to explanation, he too might arrive at something like preexistence. As a generalization, this suggestion cannot hold (though Wilkie does not present it as a general rule). One need only examine the theories of Harvey and Descartes to see examples that falsify this position.[18] But might one view the Haller-Wolff debate in these terms? If so, then it may be argued that, while Wolff's epigenetic theory of generation is indeed different from Haller's preexistence theory, this difference comes about because the two have distinct concerns. There are reasons, found in Wolff's early writings, for believing this to be true. Moreover, this possibility gains strength when we note that Wolff himself proposes something much closer to preexistence later in his life when he tries to explain elements of his generation theory that he had earlier left unexplained. While I eventually argue against the interpretation of Wolff offered in this section, it is nonetheless helpful to present it here in order to detail crucial elements of the two theories

[17] J. S. Wilkie, "Preformation and Epigenesis: New Historical Treatment," *History of Science* 6 (1967): 142–3.

[18] Descartes is occasionally taken to have posited mechanical epigenesis (e.g., Phillip R. Sloan, "Preforming the Categories: Eighteenth Century Generation Theory and the Biological Roots of Kant's A Priori," *Journal of the History of Philosophy* 40 [2000]: 233–4).

of generation, including the ways in which Wolff's later account both bears marks of preexistence and is still quite different from Haller's theory.

On one understanding, preexistence simply cannot be considered an explanation of generation because it transforms what ought to be explained naturally into a supernatural event.[19] Wolff himself believes that preexistence cannot be taken as an explanation of generation because it in fact denies generation (Wolff 1759, *Expositio et ratio instituti*, §3, 5). But under one common understanding of preexistence,[20] the theory comes about because it seems that generation could not be explained any other way given the premise of the mechanical philosophy. Descarte's own theory, according to which organic forms would emerge part after part from bits of matter moving according to the laws of nature, establishes the extreme improbability of an epigenetic account within the confines of a nascent mechanism. Given that there is no possible natural explanation of generation (according to the present interpretation), generation could occur *only* by God's forming each organic individual. So in the case of generation, turning to the supernatural provides, in fact, a *true* account of the origin of organic beings and to this extent actually explains how they come to be. Thus, the sequential emergence of parts from undifferentiated material may be an accurate description of what we can see during fetal formation, but we cannot conceive how the finished product could ever arise from matter in motion, and so epigenesis can be only a description of events seen, not an explanation of how they actually occur.

Wolff himself believes that in positing the twin suppositions of secretion-solidification and the *vis essentialis*, he is providing an explanation and not a mere description of an epigenetic generation theory because these two principles are the sufficient reason for generation (Wolff 1759, §242, 115). He draws upon a distinction adopted from Christian Wolff between historical and philosophical knowledge (a third kind of knowledge, mathematical, is not salient to the current discussion). Historical knowledge merely lays out the facts, and in the case of generation it simply provides a description of changing appearances of the developing fetus. Philosophical knowledge provides an explanation for the changing appearances, and it does so by providing the sufficient reasons for the appearances (§§5–7, 5). Wolff believes that, with the exception of Descartes before him (to be dealt with in the next section), no one had provided a sufficient reason to explain the phenomena of generation.

[19] Andrew Pyle, "Animal Generation and Mechanical Philosophy: Some Light on the Role of Biology in the Scientific Revolution," *Journal for the History and Philosophy of the Life Sciences* 9 (1987): 246.

[20] Roger, *The Life Sciences in Eighteenth-Century French Thought*, chap. 3; Bowler, "Preformation and Preexistence in the Seventeenth Century," 236.

But by positing the *vis essentialis* acting along with the secretion and solidification of nutritive fluids, he believes that he has provided a proper explanation (§242, 115) and that he has thus produced philosophical knowledge.[21]

While Wolff is justified in this claim, it is not *prima facie* clear why he is justified, and a proper account of this justification will be given in section 4. At this juncture, however, one may argue against Wolff's assertion that he has produced philosophical knowledge by pointing out that, while he has identified sufficient reasons for the emergence of organized form, he has left these reasons themselves entirely unexplained. The process of secretion and solidification of parts (one of two sufficient reasons identified by Wolff) is a mere description of the phenomena seen, namely, the fact that from "budding points" in plants, for example, globules of fluid are secreted and then gradually solidify into organic structures. The second of Wolff's sufficient reasons for generation is the *vis essentialis*, the force which is responsible for the secretion-solidification process unfolding as it does. The *vis essentialis* is meant to be the cause that brings about the effects experienced in generation. His denial that the heart is preformed is crucial for his theory because without a beating heart some other principle must be identified as the efficient cause of fetal development, thus encouraging the supposition that the *vis essentialis* is that principle (Wolff 1759, §§167–8, 72–3). Yet one might argue that it is unclear in his early works that this "cause" is anything other than a name that stands for the described progression of organic formation. This suspicion is vindicated by Wolff's discussion of the *vis essentialis* in a late essay intended to deflect criticisms of his reliance upon it:

> One could have eliminated it [the *vis essentialis*], and attributed the motion of the [nutritive] juices to other causes. Or one could have accepted no cause for the motion, and left it unexplained. Nonetheless, the motion of the juices could not be denied, and the way in which the parts are produced and formed – the main issue of a theory of generation – would always remain identical. (Wolff 1789, 50n)

Yet once Wolff admits that the supposed "sufficient reason" of the *vis essentialis* (which was meant to explain why organic development proceeds as it does) can be eliminated from our "explanations" and that we would still depict the production and formation of the organic parts exactly as we do when supposing the existence of the *vis essentialis*, the explanatory worth of the

[21] Roe, *Matter, Life, and Generation*, 103–5; Joan Steigerwald, "Instruments of Judgment: Inscribing Organic Processes in Late Eighteenth-Century Germany," *Studies in History of Philosophy of Biological and Biomedical Sciences* 33 (2002): 86–7.

concept is thrown into doubt. So it seems (1) that this "sufficient reason" does not provide much of an explanation at all but rather is an unexplained cause named as the reason for why generation proceeds as observed and described and (2) that it is the accurate description of effects that matters.

One way of bolstering the interpretation that Wolff's epigenesis is merely descriptive while also showing the divergence of Haller and Wolff in their theories of generation is to pay regard to the use each makes of forces in their theories of generation. Newton had a clear impact on the life sciences in the eighteenth century, and this is certainly true in the cases of both Haller and Wolff. As Thomas Hall points out, physiologists consciously adopted Newtonian paradigms to their own investigations of living beings. Hall calls these "physiological unknowns" or the "inexplicable explicative devices" used to explain organic phenomena which, like Newton's gravity, may be unknown as causes but are well known by their constant and predictable effects.[22] There are two elements to this adoption of forces. First, ontologically, life scientists appeal to forces as causes that explain the effects studied. And second, epistemically and methodologically, we do not know what the natures of these causes are, but we can still rely upon them in our explanations because we can study the actions of the causes and thus the effects they bring about.[23]

Haller posits two such forces – the force of irritability and that of sensibility – and he presents a detailed account of his discovery of these forces in his 1752 "Dissertation on the Sensible and Irritable Parts of Animals" (hereafter "Dissertation"). The force of irritability is the tendency, found only in muscle fiber and semen, to contract, and Haller hypothesizes that this force resides in the gluten of the irritable fiber (Haller [1752] 1936, 675). The force of sensibility, on the other hand, is the tendency, found only in nerves, to feel or sense (658–9). Haller discovered these forces through a series of vivisections that underscore the central import of experiment in his studies:

> I took living animals of different kinds, and different ages, and laying bare that part which I wanted to examine, I waited till the animal ceased to struggle or complain; after which I irritated the part, by blowing, heat, spirits of wine, the scalpel, *lapis infinalis*, oil of vitriol, and butter of antimony.... The repeated

> events of those experiments I wrote down faithfully, whatever I found them to be. (659–60)
>
> The results of all these experiments have given place to a new division of the parts of the human body... by distinguishing those which are susceptible of Irritability and Sensibility, from those which are not (657–8).

These multiple experiments lead Haller to the conclusion that the forces of irritability and sensibility surely exist – we witness the actions and effects of them – even though we are no more familiar with the nature of these forces than we are familiar with the nature of gravity (692). The force of irritability is useful for Haller, as he employs it to explain the onset of fetal growth on a preexistence theory. Given that the heart is the most irritable of all muscles (686–8), it is the first to be stimulated by the inherent irritability of the semen when the semen contacts the embryo in the uterus upon coitus. This starts the beating of the heart, the life of the fetus, and the filling out of shriveled and transparent but preexisting body parts.

Haller's force of irritability is somewhat akin to Newtonian gravity. Certainly, epistemically and methodologically it is precisely Newtonian, and Haller claims exactly this. We do not know its nature as cause, but we know it by its effects. Those effects are simple in that they are a single type of motion – the effect is simply to contract. While Haller advocates a suspension of judgment on the nature of forces, he does not suggest a suspension of research upon them.[24] Haller is also not averse to allowing that organic actions, including the effects of irritability, may well one day be subject to calculation.[25] But ontologically Haller's forces, both irritability and sensibility, are somewhat different from Newtonian gravity in that the latter is universal but the former are confined to specific sorts of organic parts within an already organized body.[26] The importance of this departure from Newton will come clear in due course.

[24] Cf. Maria Teresa Monti, "Les dynamismes du corps et les forces du vivant dans la physiologie de Haller," in *Vitalisms from Haller to the Cell Theory*, ed. Guido Cimino and F. Duchesneau (Florence: Leo S. Olschki Editore, 1997), 59–60.

[25] See Magarete Hochdoerfer, *The Conflict between the Religious and the Scientific Views of Albrecht von Haller (1708–1777)* [1932], reprinted in Shirley Roe, *The Natural History of Albrecht von Haller* (New York: Arno Press, 1981), 11 ff., and Maria Teresa Monti, "Les dynamismes du corps et les forces du vivant dans la physiologie de Haller," 46ff. and 64, for Haller's equivocal attitude to the use of mathematics in investigations of life phenomena.

[26] Duchesneau, "Haller et les theories de Buffon et C. F. Wolff sur l'épigénèse," 77–8; Duchesneau, *La physiologie des lumières*, 284 ff.; Brigitte Lohff, "The Concept of Vital Forces as a Research Program: From Mid-XVIIIth Century to Johannes Müller," in Cimino and Duchesneau, *Vitalisms from Haller to the Cell Theory*, 127ff. For a discussion of whether or not Haller's irritability is

Wolff also relies upon the concept of force – his *vis essentialis* – throughout his discussion of the generation of living beings (animals and plants) and their self-maintenance (plants). His force is also akin to Newton's force of gravity epistemically in the sense that we cannot know its nature, but its existence as a cause of living processes is clear to us due to the regular effects it brings about: "It suffices that we know it is there, and to identify it by its effects, as it is required purely and simply so as to explain the development of parts" (Wolff 1764, 160). Just as Haller's forces are nonuniversal and confined to the body of organic structures, so too is Wolff's *vis essentialis* unique to living beings. Moreover, no less than Haller's forces, Wolff's force is not connected with a soul. But Wolff's *vis essentialis* is different from Haller's forces in at least two ways. First, while it is unique to living beings, it does not require an already existing organic structure in order to be brought forth. While Haller's forces of irritability and sensibility can only emerge once such a structure is in place, Wolff's *vis essentialis* is responsible for bringing such a structure into existence. And so, second, its effects are not simple linear contractions but the quite complex development of a heterogeneous, integrated form from homogeneous matter. Haller's insistence that his force of irritability has no shaping or forming capacity at all (EP 4:64; EP 8:112) thus sets his force squarely apart from Wolff's *vis essentialis*, which, at least in Wolff's early work, would seem to have to accomplish exactly this.

These last differences might well be the locus of the distinction Roe makes between Haller as a mechanist and Wolff as more of a vitalist. Some commentators believe that even Haller himself might be taken as a vitalist, since, after all, he no less than Wolff identifies forces that only living beings possess – life forces of some sort.[27] But Haller is determined to disavow vitalism: "Some famous men have recently called this [irritable force] a 'vital force,' a name I do not like at all.... I prefer to call this the muscle's implanted or proper force" (EP 4:64). Wolff is similarly determined to reject "mechanical medicine" precisely because one cannot explain what an animal does in terms of what a machine might do; only the former can build, grow, and maintain itself (Wolff 1759, §255, scholium 1, 125–6). So it may be possible to make a distinction between Haller as mechanist and Wolff as vitalist in this way: both

a force in the Newtonian tradition, and for a general discussion of force and vitalism in Haller, see Maria Teresa Monti, "Les dynamismes du corps et les forces du vivant dans la physiologie de Haller," 56ff.

[27] Dietrich von Engelhardt, "Vitalism between Science and Philosophy in Germany around 1800," in Cimino and Duchesneau, *Vitalisms from Haller to the Cell Theory*, 161; Richard Toellner, "Principles and Forces of Life in Haller," in Cimino and Duchesneau, *Vitalisms from Haller to the Cell Theory*, 31.

may conceive of the product of generation as unique – living beings are not reducible to machines (nor to other naturally organized forms such as crystals) because they include a force unique to living beings – yet they conceive of the process by which this product comes to be in distinct ways. Precisely because Haller's living forces have simple, linear effects, they cannot form a precisely organized, complex living body. Nor can such a nonpurposive force form a living body that manifests purposive functionality. So these natural, living forces cannot explain generation. In contrast, Wolff's force is posited precisely as the source of organic formation and so cannot be merely simple and linear. Therefore, since Haller's force requires the existence of a living structure, it is parasitic upon and emerges from that structure. And since Wolff's force is posited as the source of living structures, it is primitive and fundamental. Haller's living forces cannot account for all living functions because generation is precluded, but Wolff's living force can account for all living functions. Hans Driesch takes vitalism to be a theory about the unanalyzable autonomy of living beings, but this must mean that they are autonomous in their generation as well as in every other function.[28] So taking a basically Drieschian theoretical approach, the divide between Haller as mechanist and Wolff as vitalist can be reached by noting the capacities of the latter's living force to affect all organic phenomena including generation.[29]

By focusing on the way in which Wolff employs the *vis essentialis* to account for generation, we see how one might charge him with simply describing (and not explaining) generation by claiming it is accomplished

[28] Driesch, *The History and Theory of Vitalism*, 1914, 1–6.

[29] While this may provide an internally nonarbitrary way of distinguishing between vitalism and mechanism, and of categorizing Haller and Wolff, it must be borne in mind that there are many other equally legitimate ways of distinguishing between vitalism and mechanism. See, e.g., François Duchesneau, "Vitalism in Late Eighteenth-Century Physiology: The Cases of Barthez, Blumenbach and John Hunter," in *William Hunter and the Eighteenth-Century Medical World*, ed. W. F. Bynum and Roy Porter (Cambridge: Cambridge Univerity Press, 1985), and Hilde Hein, "The Endurance of the Mechanism-Vitalism Controversy," *Journal of the History of Biology* 5 (1972): 159–88. In this paper, I leave aside the broader question of whether there is any meaningful way of achieving such a distinction, especially given the myriad ways in which vitalism and mechanism are defined. For an example of the difficulty, see Maria Teresa Monti, "Les dynamismes du corps et les forces du vivant dans la physiologie de Haller," including her struggle to come to terms with the question whether Haller's physiology is mechanist or vitalist and the arguments that might be launched in favor of either approach. See also Duchesneau, *La physiologie des lumières*, 338, for a similar discussion regarding Wolff. See also Bernard Balan, *Génération, organisation, développement: L'enjeu de l'épigénèse: Entre forme et histoire: La formation de la notion de développement à l'âge classique* (Paris: Meridiens Klinksieck, 1988), 115, for his claim that Wolff shared a mechanistic style of explanation with Descartes. But see the next section of this paper for my contrasting view of the methodological elements Wolff shares with Descartes.

through epigenesis. This is because of the Newtonian epistemology that grounds his theory of the *vis essentialis*: we may not know what the force is as a cause – we may not know what its nature is and how it accomplishes what it accomplishes – but we know that it exists by studying the effects that it surely does have, such as the process of generation. Yet studying these effects seems to amount to no more than describing the constant and regular sequential development of parts, a development not even subject to calculation. Contrast this with Haller's approach, which admittedly starts with a description of the effects of living forces. But because these forces are simple and linear, they cannot satisfactorily explain generation. Only God, believes Haller, is up to the task, and so acknowledging the truth of God's role in generation is an accurate explanation of that process. It is more than mere description.

The conclusion that Wolff describes but does not explain generation through his theory of epigenesis is encouraged by his later works. In his 1789 paper *Von der eigenthümlichen und wesentlichen Kraft der vegetabilischen sowohl als auch der animalischen Substanz*, Wolff writes that "through this present treatise, this essential force, which I posited at that time [in earlier works] as the foundation which I also proved existed, but which I in no way explained, now will be explained" (50n). In doing so, he contrasts his *vis essentialis* with Blumenbach's *Bildungstrieb*, or formative power, since the *vis essentialis* "exists in nothing further than a particularly defined kind of attractive and repulsive force" which draws like substances together and drives unlike substances apart (42).[30] Not only is the *vis essentialis* not to be equated with the soul, but it is not to be understood as selective and purposive, capable of accomplishing different things from moment to moment, as Blumenbach's force would seem to do. This is because there would be no sufficient reason why it would act in these different ways precisely as it does and in no other way (66n). Wolff thus echos Haller's own earlier stated concern regarding the *vis essentialis*: there is no reason why a hen should produce a chicken while a peacock produces a peacock (EP 8:117). Wolff concludes that the principle of sufficient reason, as he understands it, requires that we reject the idea of a purposeful, determining building force that can produce myriad effects because there would be no necessary connection between such a force and its actual very precise effects. Because there is no necessary connection, in reality it should thus be unpredictable in what it does (Wolff 1759, 67). In his criticism of Blumenbach, and in his definition of the *vis essentialis* as a nonselective attractive or repulsive force, Wolff places himself squarely in

[30] For one discussion of Wolff's denial that his *vis essentialis* is like Blumenbach's force, see Müller, "La conception de l'épigénèse chez Caspar Friedrich Wolff (1734–1794)," 350 f.

Haller's camp with regard to the simplicity of effects brought about by the force found in living beings. And just as Haller was skeptical about being able to account for the creation of the complexity of the living body on the basis of such a simple force, so too is Wolff. Part of his solution to this new obstacle is to postulate not just one *vis essentialis* but a number of nonselective attractive forces as causes that bring about the activity of generation (66).[31] Further, and crucial for our concerns, there are "countless other concurring causes" which guide the formation of the embryo (67).

One of these concurring causes comes clear in his unpublished notes, *Objecta meditationum pro theoria monstrorum*, which are concerned with explaining the generation of monsters in light of the facts that like usually generates like (inheritance of specific traits), that children often resemble their parents or other relatives (inheritance of familial traits), and that individuals nonetheless are usually unique (variability). Wolff here suggests the new hypothesis that the initial matter of generation is already conditioned in certain ways, for he now believes there must exist various forms of "qualified vegetable matter" (*materia qualificata vegetabilis*), or vegetable substance (*substantia vegetabilis*), each of which vegetates in its own fashion. In every vegetative body, writes Wolff, there are three aspects to vegetation. First, there is the act of vegetation itself, which produces the animal or plant as such and is thus responsible for generation in general; second, there is the mode of vegetation, which produces the species; and third, there is the degree of vegetation, which produces individual variety within animal and plant species (Wolff 1973, 168).[32] Qualified vegetable matter is relevant to the first two aspects of the vegetative process. It is in the essence of qualified vegetative matter to vegetate, and it therefore contributes to generation *per se*, and each sort of qualified vegetable matter vegetates in its own manner or mode, thus contributing to species production (Wolff 1973, 158, 171). As Wolff writes: "[I]n any soil and any climate they [plants] have their special structure which they create *for themselves* [emphasis added]. Therefore . . . neither the climate nor soil but the plant in its diversity, its growing qualified matter in the process of growth, creates the structure and form." Further, it is because of their specific qualified vegetable matter that plants "preserve not only the ability of vegetation [which produces organisms as such] but also their qualification . . . maintaining the species" (Wolff 1973, 181, 186; trans. Gaissinovitch 1990; 193–4). This already somewhat predetermined material

[31] For an alternative account of the evolution of Wolff's concept of the *vis essentialis*, see Mocek, "Caspar Friedrich Wolffs épigénèsis-Konzept."

[32] Cf. Roe, *Matter, Life, and Generation*, 129–30.

which determines species is passed from generation to generation, from parent to offspring, while no organic structure is so transmitted because the species consists in the cause of the structure (and that cause is the qualified vegetable matter); the species does not consist in the structure itself:

> [I]n vegetation and generation there exists something that is associated with the specific structure observed, and the basis of this structure. The latter – all that could be called *the inner* – is hidden from us.... Only this is transmitted from the parents to the offspring by way of generation; the former [the specific structure] emerges in the offspring as the result of that which is transmitted. (Wolff 1973, 155; variation of translation in Gaissinovitch 1990, 189)

Moreover, this transmitted qualified vegetable matter has its ultimate origin in God, for this alone can explain the replication of species from generation to generation. Species, then, are eternal and have existed, as we now know, from the Creation. The supposition of qualified vegetable matter as the bearer of specific traits "altogether proves [the existence] of the primary reasonable acting cause," as it depends upon "God's providence" (Wolff 1973, 187; trans. Gaissinovitch 1990, 194).

Recall Roe's belief that one of the "extrascientific" factors motivating the divergence in generation theories between Haller and Wolff is the greater role for a providential God in Haller's natural philosophy.[33] In light of Wolff's later philosophy, it is far from clear that this belief can be sustained. Once Wolff starts to ask how the *vis essentialis* produces a fetus, and once he starts to investigate why species produce like kinds – that is, once he turns to seeking explanations for *how* generation occurs as it does – he must turn to God in order to answer these sorts of questions. According to Haller, at the Creation, God produced organic structures and endowed matter with the forces of irritability and sensibility (EP 7:xii), as this alone could explain organic processes, including generation. According to Wolff, at the Creation, God created various types of qualified vegetable matter, each with its mode of vegetation, as this alone could explain generation of species from like kinds. Though they differ in what they believe God created at the Creation, Haller and Wolff both do appeal to God's providence and foresight as an essential element in their theories of organic generation, a point Wolff draws to Haller's attention in his letter of April 17, 1767 (Wolff [1759–77] 1981, 168).[34] This

[33] Shirley Roe, *Matter, Life, and Generation: Eighteenth-Century Embryology and the Haller-Wolff Debate*, 90–2 and 119.

[34] Margarete Hochdoerfer believes that Haller maintains a basic belief in the divine order of the universe, whether that order is expressed in terms of preexisting germs formed directly by God or laws of epigenesis that will produce organic order (*The Conflict between the Religious and*

will not, however, be the last word on the role played by God in these two naturalists' theories.

So Wolff abandons the theory of epigenesis as he had previously understood it. Once he queries the way in which the *vis essentialis* operates, and concludes that it is simple, nonselective force, he posits a variety of special substances created by God and passed from generation to generation in order to explain the results of generation. Once Wolff turns from describing the process of generation to explaining how this process is brought about, he moves decisively in the direction of preexistence in the sense that he turns to God's having predetermined to a considerable degree the matter of generation. Moreover, Haller's belief, as one example, that the preexisting structure created by God is merely an organized fluid that, upon conception, develops boundaries and a consistency that can resist pressure (Haller 1758, 2:175) indicates the strong epigenetic elements to be found in his theory: there is, in an anatomically significant sense, notable organic development. If the preexistence-epigenesis divide is to be meaningfully retained in the case of Haller and Wolff, we must provide a more careful explication of the distinction between the two theories than has thus far been given.

3. HALLER AND WOLFF ON DESCARTES

Roe is surely correct when she writes,

> Admittedly, embryos on Wolff's theory do not start out in a state of absolute homogeneity. Yet one must be careful not to define epigenesis so narrowly that clearly epigenetic systems like Wolff's are excluded. Gradual development of complex heterogeneity from simple heterogeneity can provide a valid epigenetic viewpoint. In Wolff's system, the embryo's initial heterogeneity is of a potential nature, based only on physical factors like solidification and attraction and repulsion, which produce the structures of the organism through a gradual, but automatic, sequence of events. This is a far cry from preformation, especially in its eighteenth-century *emboîtement* form.[35]

Haller insists that what God created and what is passed on from generation to generation is a fairly complete structure of well-integrated essential organs (EP 8:148–9). Wolff emphatically denies that physical structure is what is passed from generation to generation since what is passed on – the species – is

the Scientific Views of Albrecht von Haller (1708–1777), 9). If she is right, then this would reinforce Wolff's point in his letter to Haller, that God need not work in the world by creating all organisms at the Creation in order to work providentially in the world.

[35] Roe, *Matter, Life, and Generation*, 147.

simply a mode of vegetation (Wolff 1973, 154): "the thing which is, in the beginning, excreted from or produced by the maternal ovary is none other than the drop of liquid located in the egg in which there is no structure similar to the structure of the parent" (Wolff 1973, 149; trans. Gaissinovitch 1990, 188). So if we define, reasonably, preexistence as the passing on of the essential structure from generation to generation, and if we define epigenesis as the development of the essential structure where there was no such organic form before, even if the matter of generation is differentiated in a nonstructural way so as to necessitate a specific physical form, then the portrayal of Haller as preexistence theorist and Wolff as epigenesist holds.

But this, then, raises a crucial question. Why does Wolff posit matter that is somehow informed but not structurally formed, contrary to Haller's view? There are many viable answers to this question, but the one I will pursue requires that we reconsider Wolff's earlier account of generation in order to determine why he thinks that it is an explanatory account of organic formation and development when it seems to be a mere description of the process. This brings us to the other fundamental issue of this essay: how experimental techniques, in the case of Haller and Wolff, condition the way they experience the data and consequently influence the theories of generation that they adopt. To set the stage for this work, I deal first with Haller's and Wolff's different reactions to Descartes in order to clarify their epistemologies and thus their methodologies in natural investigations.

Haller is emphatic about the need to place experiment and observation above rational speculation and theory building. This should be clear by the fact of his extensive research on chicken eggs and his vivisections of 190 animals during his investigations into sensibility and irritability, a "species of cruelty for which [he] felt such a reluctance, as could only overcome by the desire of contributing to the benefit of mankind" (Haller [1752] 1963, 657). In the preface to the German translation of Buffon's first volume of the *Histoire naturelle*, he writes, "[M]ore convenient telescopes, rounder glass drops, more accurate divisions of the yardstick, syringes, and scalpels have contributed more to the enlargement of the domain of science than the creative spirit of Descartes, the father of classification, Aristotle, and the erudite Gassendi" (Haller 1750, x). Descartes, in Haller's estimation, misuses hypotheses because he starts from them rather than starting from observation and experiment. According to Haller, Descartes consequently speculates in the complete absence of empirical data. Haller is wrong, of course, that Descartes failed to conduct adequate experiments. In fact, Descartes is reluctant to put pen to paper to tackle the problem of generation because he has not had enough opportunity to conduct enough experiments (AT 5:261), even

though, in a letter to Mersenne of February 20, 1639, he reports having spent eleven years doing dissections in order to further his knowledge (AT 2:525, CSMK 134–5). Still, Haller is correct that rational theorizing comes first for Descartes in the sense that his theory of matter as extension is arrived at through the use of the pure intellect and that his matter theory sets limits upon any scientific explanation he can give of the empirical data.

Wolff, conversely, praises Descartes. Descartes "showed what a proper explanation must look like, and he taught how one must philosophize" (Wolff 1764, 6). The reason Wolff thinks that Descarte's attempt at explanation is so successful is that he follows the method which Wolff lauds: "the only clear demonstration is to prove that if laws and principles are assumed an organic body necessarily follows, or to show the sufficient connection between principles and laws and the generated organic body" (Wolff 1759, §§6–7, 5). This is what Wolff believes he himself is doing when he posits the secretion and solidification of nutritive juices together with the *vis essentialis* as the sufficient reasons for the organic body. Descartes goes wrong, Wolff believes, in his theory, but at least he followed the correct method.

Roe takes Haller's rejection of Descartes and Wolff's praise of him as evidence of Haller's empiricism and Wolff's rationalism.[36] But this is an odd claim to make in light of these facts: that the theory of preexistence is surely as divorced from experimental proof as a theory could be (there is no possible way of observing God creating all living beings at the Creation); that Wolff himself is an avid experimentalist and relies heavily upon experimentation in developing his theory of epigenesis; that Wolff also expresses hostility to hypothesis in a November 16, 1765, letter to Haller (Wolff [1759–77] 1981, 165);[37] and that of the two of them it is Haller who propounds nonempirical theories such as the supposed transparency of parts (Wolff 1764, 126, 188). A closer examination of Haller's and Wolff's reactions to Descartes establishes that what Haller criticizes in Descartes is not what Wolff praises and that Wolff can agree with Haller's criticism of Descartes while still lauding Descartes for providing the correct kind of explanation. Despite Descarte's own reluctance to speculate on generation in the absence of any relevant experiments, and despite the fact that he eventually did observe fetuses in various stages of growth, Haller seems to believe that Descarte's system of generation is built upon speculative causes considered completely in isolation from effects realized. This is what he criticizes in Descartes. Wolff praises the ability to

[36] Roe, *Matter, Life, and Generation*, 105.

[37] Duchesneau, *La physiologie des lumières*, 294.

give an account of causes sufficient to show that a given effect is the necessary outcome. But this is compatible with a rejection of what Haller finds objectionable, specifically theorizing about causes in the complete absence of experience. That is, Wolff can criticize Descartes for providing the wrong principles and laws – such as the assertion that all organisms are generated from the motion of matter of certain sizes, shapes, and so forth – because these are arrived at through speculation. But Wolff can still commend Descartes for providing the right *kind* of explanation (i.e., for showing how these [erroneous] causes and principles necessarily yield an organic body). The fact that Wolff thinks Descartes gets the details of the explanation of generation wrong suggests he might accept Haller's criticism of Descartes while also believing that Descartes nonetheless proceeded in an appropriate explanatory manner by positing principles and laws and proceeding to show how these would (at least in Descarte's view) necessarily produce an organism. We need, therefore, to reconsider Roe's claim about Haller's empiricism and Wolff's rationalism to make sense of their epistemologies and methodologies. This will entail in turn a rejection of the depiction developed in section 2 of Wolff's early theory of epigenesis as descriptive rather than explanatory.

4. EXPLANATION, EXPERIMENT, CAUSES

One of Haller's criticisms of Wolff during their dispute over their observations of chicken eggs is that Wolff (according to Haller) erroneously assumes that what is not seen is not there (Haller 1760, 1226–9). It does, indeed, seem to be the case that this is the basis of Wolff's theory of epigenesis (encouraging all the more the supposition that the "theory" is mere description of the observed):

> No one has yet seen parts with the aid of a stronger lens that he could not also see through weaker magnification. These parts either have not been seen at all or have appeared of sufficient size. It is a fable, then, to suppose that parts may remain concealed on account of their infinitely small size and then gradually emerge. (Wolff 1759, §166, 72)

In response to Haller, however, Wolff says that he is not asserting that what is not seen is not there. Rather, Wolff believes that he has based his theory of generation by epigenesis on having positively seen the development of organic parts that previously did not exist (Wolff 1764, 87–8). What justifies Wolff's claim?

Gerhard Rudolph draws our attention to Haller's "Baconian" method:

> [E]xperimentation is not mere observation but the willful and thoughtful provoking of an experience.[38] This is true too of Wolff; but the way in which the two naturalists manipulate and intervene in their experiments is critically different. Throughout the first twenty-four sections of the *Theoria generationis*, Wolff describes how he experimentally demonstrates the actions of the *vis essentialis*. By using instruments such as scalpels and needles, he actively takes on the role of that force to imitate its actions upon the nutritive fluids found in plants, thereby showing how the effects of generation follow from that cause. For example, he uses a needle to jiggle the nutritive juices in plant roots and stems in order to show how the *vis essentialis* would redistribute the fluid and even how it would create new vessels through which the fluid would be secreted (Wolff 1759, §§1–24, 12–18). This is highly interventionist and manipulative in a particular way: Wolff's instruments *become* the *vis essentialis* for the purposes of demonstration and thus for the purposes of giving a proper explanation. Wolff does not explain the *vis essentialis* in the sense of explaining its nature, nor why it exists and acts as it does. But he does explain the *vis essentialis* by claiming that it does exist (a claim based on its effects such as the generation of living forms) and, crucially, by demonstrating that it operates in such-and-such a manner.[39] This gives us a way of revisiting Wolff's reaction to Descarte's mode of explanation. According to Wolff, explanations require that we explicate causes from which the effects can be deduced, and Descartes provided an explanation of generation by satisfying this requirement. But an explanation is a mere "proposition that lacks a demonstration," and a demonstration must be added to any explanation (§255 scholium 2, 127); Descartes did not do this (and he could not provide a demonstration because the causes he posited were subsensible sizes, shapes, and speeds of bits of matter). Wolff, once again, could accept Haller's criticism of Descartes – that his theories are too speculative – while still praising Descartes for providing adequate explanation, yet also faulting Descartes for not providing a demonstration of the explanation. Wolff, then, demonstrates experimentally how a sequence of actions brought about by the *vis essentialis* would necessarily produce the effects he details in his explanation of generation.

[38] Gerhard Rudolph, "La méthode hallérienne en physiologie," *Dix-Huitième Siècle* 23 (1991): 78.

[39] Duchesneau alerts us to another element of Wolff's experimental demonstration that is not at odds with the depiction here (*La physiologie des lumières*, 330). Wolff has a double scheme of demonstration, first providing an account of vegetation "in abstract," by laying out the order of generation in general according to the supposed law of epigenesis. Second, Wolff examines the question of generation in "inverse" order, by starting with an examination of the nutritive actions of the *vis essentialis* in the fully grown adult (e.g., in digestion), then deriving the probability that there are laws governing these actions, and finally arguing by analogy that there must be a law governing generation by epigenesis.

> Haller, too, is willfully interventionist and manipulative in his experimentation. Dissections will not suffice to give the experimenter the information she needs about the living organism, and so she must perform vivisections so that the living tissue can be manipulated in various ways.[40] We get multiple examples of this manipulation in his "Dissertation," such as the experiment of pricking the bladder of a nearly dead dog to see whether it would still contract and expel urine (Haller [1752] 1936, 682). As another example, in a letter to Bonnet of August 25, 1765, Haller describes experiments he performed in an attempt to determine the nature of the changes that happen to the blood vessels in the membrane surrounding the embryo in an egg in the first few days after fertilization. Specifically, he wants to determine whether these changes indicate a new formation or merely the becoming visible of the previously invisible, and to determine this he uses a scalpel to poke at the vessels both in an early stage when they are still yellow and at the later stage when they become red with blood. By poking and moving these lines around, the color in them does not spill out of the pathways as would be expected if the vessels were not yet formed and closed, and the lines of color return to their original positions once the scalpel is removed, thus indicating that these are, indeed, fully formed and closed vessels even at the earliest stage of organic life. (Haller [1754–77] 1983, 436–7)

In the experiments meant to elucidate the actions of the forces of irritability and sensibility, however, Haller is interventionist in a different way than is Wolff in the latter's attempts to elucidate the actions of the *vis essentialis*. He manipulates the environmental conditions in order to bring forth the causal actions of the forces of irritability and sensibility, but it is the force itself that is causally active in Haller's experiments. He does not imitate or mimic or take on the role of the force in order to show how (by what series of events or by what process) it produces its actions and effects. In this way, by Wolff's lights, Haller would not have produced an adequate demonstration of those forces. Both Haller and Wolff claim ignorance regarding the nature of the forces they posit. But Wolff believes that, through his demonstrations, he can claim knowledge of at least some of the steps or part of the process by which the *vis essentialis* brings about its effects, and Haller can make no such claims about the process by which the forces of irritability and sensibility produce their actions. Wolff, then, believes that he can answer the question of how (through what steps, by which process) the *vis essentialis* produces its result, while the best Haller can do is to explain under what circumstances the forces might act and how the effects they produce appear to us (e.g., as nonselective

[40] Rudolph, "La méthode hallérienne en physiologie," 79.

contracting forces); he cannot explain, however, how the forces produce these effects.[41]

Haller's experiments to identify the forces of irritability and sensibility presuppose the existence of a specific organic structure made up out of organic material.[42] He is looking for the parts of the human body that have the capacity to be stimulated to exhibit irritability and sensibility, and so the parts are already assumed. At least insofar as his investigation into the forces of living bodies is concerned, then, Haller's experiments are premised on the assumption that living functions and living structure are inseparable and mutually interdependent,[43] indeed, so much so that without the structure the functions cannot occur, and without the functions the structure cannot endure. Unless there is an organic being that has at least its essential parts fully integrated and connected, there will be no living function (EP 8:278). This is why generation (the function of bringing forth an integrated organic form) by epigenesis (the gradual formation and integration of organic structure, part after part) is epistemically impossible.[44] In claiming this, he is echoing a misgiving that Harvey himself has about his own theory of generation by epigenesis. It is a "paradox," Harvey admits, that "the body is nourished and increased before the organs dedicated to concoction, namely, the stomach and the viscera, are formed" (Harvey [1651] 1981, 295). And, again, "it seems a paradox to say that the blood is created and made to move and imbued with vital spirit before any organs for making it or giving it movement exist" (294). One way of solving the paradox is Haller's way: presuppose the essential structure by claiming that God created it because nothing natural could *function* prior to the structure in order to bring the structure into existence.[45] A second way of solving the paradox is Wolff's way: ask a different question. Do not ask how the *vis essentialis* could possibility function outside of an organic structure, but rather demonstrate that it does. Ask how (as a matter of fact) it produces

[41] For a general account of Haller's methodology, including his experimental approach, see Maria Teresa Monti, "Difficultés et arguments de l'embryologie d'Albrecht von Haller: La reconversion des catégories de l'anatome animate," *Revue des Sciences, Philosophiques et Théologiques* 72 (1988): 301–12.

[42] Engelhardt, "Vitalism between Science and Philosophy in Germany around 1800," 166.

[43] Duchesneau, *La physiologie des lumières*, 296–7.

[44] Duchesneau, "Haller et les théories de Buffon et C. F. Wolff sur l'épigénèse," 88 ff. Amor Cherni, "Haller et Buffon," 278 ff.

[45] See Duchesneau, *La physiologie des lumières*, 289 ff. for a treatment of preexistence as more probably true of the world than epigenesis. See also Duchesneau, *La physiologie des lumières*, 297, for an account of epigenesis as epistemically impossible. Two elements of organic formation that contribute to its epistemic impossibility are the facts of the production of extreme complexity from relative simplicity and the production of a functioning structure from a natural cause that lacks intelligence.

the results that it does, and then reproduce the process by way of a demonstrated explanation. Duchesneau perceptively identifies this divide as Wolff's departure from Haller's philosophy of organic functions in favor of a new such philosophy.[46]

This different philosophy of functions brings us back to theology, and we can now see the weight behind Roe's claim that God plays a much more significant role in Haller's theory than he does in Wolff's. For both, God created something essential for generation at the Creation. According to Haller, God created the essential structure of each organic form together with the forces found within some of the matter of these structures (EP 7:xii). For Wolff, God created the various forms of vegetative matter which account for the continuity of species from generation to generation. For both, God must be involved to explain the regularity, order, and reasonable variation that we experience in the living world. But for Haller, the irreducibly teleological nature of the structure requires an intentional, intelligent builder as the source of the usefulness of the structure. That is, his philosophy of function as one that attributes usefulness for achieving certain functional goals of various structures implies the presence of an intellect, the source of which must be God, for it cannot be found in matter or forces. For Wolff, there is no such assumption about the need for structure in order to permit useful, goal-directed functions. Rather, he starts with the functioning *vis essentialis* and demonstrates how (in terms of process) this force can bring forth a structure without worrying about how the developing organism can do this minus a preexisting structure. It is enough for explanation that he has demonstrated that it does so.[47]

How, then, are we to think about Roe's claim about Haller's empiricism and Wolff's rationalism? It is true that Wolff is looking for the sufficient reason by which to explain generation, but for him this amounts to a demonstration of the proximate causes of generation only. And even then it amounts to a demonstration only of how the proximate causes accomplish the task and not an investigation into their nature nor why they proceed as they do. Perhaps for this reason, Wolff claims to be searching a posteriori for the principles and laws of generation (Wolff 1759 §71 scholium 2, 38). It is true that Wolff turns to God's initial creation of the various forms of qualified vegetable

[46] Duchesneau, *La physiologie des lumières*, 315.

[47] Hochdoerfer says that Haller was also influenced by the Biblical story of Creation in upholding preexistence (*The Conflict between the Religious and the Scientific Views of Albrecht von Haller (1708–1777)*, 31). This story provided him with a more direct reason for believing that God is needed for generation than the indirect reason suggested in the text of this paper, namely, that observations of functional organic structures indicate that there must exist an intellect responsible for that structure, an intellect for which God could be posited as the probable source.

matter to account for the continuity of species and as a necessary element of generation, but we still need a philosophical explanation for the process by which the *vis essentialis* and the qualified vegetable matter produce living beings. And this requires demonstrating, as Wolff does in his treatise, the actions of the proximate cause by taking on, through the manipulation of instruments, the role of the cause. If Wolff is a rationalist, he is one who uses experiment to demonstrate empirically the action of the causes with which he is primarily concerned: proximate efficient causes.

Haller surely relies heavily upon the empirical. His anatomical starting point establishes this. But his appeal to God as the efficient cause of the generation of all organic forms just as surely establishes his reliance upon speculation reached through reason. Indeed, strictly speaking, his experiments on developing chickens can establish pre*formation* at best and not preexistence. Haller's appeal to God as efficient cause of generation also precludes the possibility that he, like Wolff, is searching for a natural proximate cause of generation. Some commentators have taken this turn to God as a breakdown of Haller's own strict adherence to experiment. John Neubauer, for example, believes that Haller's religious commitments, together with the especially hard case of fetal formation, force him in the end to abandon his own empirical commitments, thus exposing an irreparable rift between science and religion in his thought.[48] I am more swayed by Maria Teresa Monti's and Richard Toellner's approach, which is to argue that there is unity in Haller's thought.[49] This entails granting Haller his empiricist credentials and recognizing that it is true that observation and experiment are crucial to him. But his empirical study of the anatomical structure of fully formed organisms predates his investigations of developing chicken embryos – his "Dissertation" was written in 1752 but his first articulation of his mature endorsement of ovist preexistence did not appear until 1758. Moreover, anatomy is conceptually prior to physiology, for Haller, and the latter depends upon investigations pursued in the former (e.g., Haller 1747, 5; Haller 1777). Whatever else anatomy may include, for Haller, it certainly includes the study of organic structure and the functions of specific organic parts. And he consistently includes generation in his physiological treatise (Haller 1747; EP 8), thus implying that a study of generation is conceptually posterior to and parasitic upon empirical findings regarding

[48] John Neubauer, "Albrecht von Haller's Philosophy of Physiology," *Studies on Voltaire and the Eighteenth Century* 215 (1983): 321; cf. Neubauer, "La philosophie de la physiologie d'Albrecht von Haller," *Revue de Synthèse*, nos. 1-13–14, p. 135–42, and Hochdoerfer, *The Conflict between the Religious and the Scientific Views of Albrecht von Haller (1708–1777)*, 13–14.

[49] Monti, "Théologie physique et mécanisme dans la physiologie de Haller," *passim*, esp. 71; Toellner, *Albrecht von Haller*.

functioning structures.[50] An empirical study of anatomical structures and their functions, then, leads Haller to hypothesize God as the only possible efficient cause of organic formation. It is true that Haller's empirical findings force him to a rationalism beyond anything we find in Wolff. But Haller is an experimentalist in the end, too, for he resolutely pursues experiment after experiment to garner empirical support for the very early existence of hidden organic parts, in order to match and surpass Wolff's experiments and thereby pose a constant challenge to epigenesis (Haller [1754–1777] 1983, 418).

Haller and Wolff, then, clearly embrace distinct theories of generation. We may call these preexistence and epigenesis only if we acknowledge the strong strand of preexistence theory in Wolff's mature view and only if we acknowledge that there is tremendous development of the fetus (development brought on by natural means) on Haller's view. Still, the difference remains: for Haller, the essential structure must be formed by God, a belief Wolff rejects. One source of this difference is the nature of their interventions and experimental techniques throughout their investigations on living beings. Wolff intervenes to reproduce the causal action of the *vis essentialis* and thus claims to have truly explained generation. He need not, according to this conception of explanation, deal with the more abstract questions of the relation of structure and function in organic bodies. But Haller must deal with such questions because the primary object of study in his early experiments is the completely structured animal, and this conditions what he must observe when turning his attention to fetal formation.

[50] For an account of the disciplinary boundaries between anatomy and physiology before 1800, together with the shift in these boundaries after 1800, see Andrew Cunningham, "The Pen and the Sword: Recovering the Disciplinary Identity of Physiology and Anatomy before 1800," pt. 1, "Old Physiology – the Pen," *Studies in History and Philosophy of Biological and Biomedical Sciences* 33 (2002): 631–65; pt. 2, "Old Anatomy – the Sword," *Studies in History of Philosophy of Biological and Biomedical Sciences* 34 (2003): 51–76.